No. 3108

IN THE

United States Circuit Court of Appeals

NINTH JUDICIAL CIRCUIT

GEO. J. HENRY, Jr.,
Appellant

vs.

CITY OF LOS ANGELES,
Appellee

Appellant's Copies of Printed Exhibits

RAYMOND IVES BLAKESLEE,
Counsel for Appellant

UNITED STATES PATENT OFFICE.

CARL S. ENGLISH, OF LOWELL, MICHIGAN, ASSIGNOR OF ONE-HALF TO CHARLES A. CHURCH AND OTTO C. McDANNELL, OF SAME PLACE.

ELECTRICAL GOVERNOR FOR WATER-WHEELS.

SPECIFICATION forming part of Letters Patent No. 521,085, dated June 5, 1894.

Application filed December 23, 1893. Serial No. 494,599. (No model.)

To all whom it may concern:

Be it known that I, CARL S. ENGLISH, a citizen of the United States, residing at the village of Lowell, in the county of Kent and State of Michigan, have invented a certain new and useful Electrical Governor for Water-Wheels, of which the following is a specification.

This invention relates to a new and useful governor for water-wheels.

The invention has for its object to provide novel mechanism for automatically regulating the supply of water to a water wheel that is utilized to generate power for an electric dynamo, in such manner that the amount of water supplied to the wheel, and consequently the power developed by the wheel, shall be increased and diminished in proportion to the amount of work required to be performed by the dynamo, and to this end my invention consists in the novel construction, arrangement and combination of parts hereinafter fully described and afterward definitely pointed out in the claims following the description, reference being had to the accompanying drawing forming a part of this specification.

In the drawing I have shown in elevation a portion of the conductors used in connection with a dynamo, together with suitable mechanism for controlling secondary currents generated by means of a battery or other suitable electrical power, together with connecting mechanism for operating upon the shaft which controls the gate that allows the water to flow upon the water-wheel or water-motor.

I have not illustrated the dynamo nor the water-wheel, for the reason that I make no claim to the form or shape of the dynamo or water-wheel, it being well understood that any form of gate or gates may be used for the purpose. I have also shown my preferred form of applying power, but it will be evident that various changes of form may be used without departing from the spirit of the invention.

In the drawing Z, represents a coil composed of a coarse wire and a fine wire, the coarser coil wires being shown by S, and the finer one by *n*. The object of using the coarse and fine wires is for the purpose of obtaining a more accurate adjustment, as hereinafter more fully described.

i represents the needle or arm which is acted upon by the magnetic influence of the coil Z. The arm *i*, is pivoted at 2, and is provided with projections 3 and 4, which projections are adapted to come in contact with the contact points C′ and C², in order to connect the electric circuit, as hereinafter described. By winding the needle *i*, with a suitable wire coil, it is made an electro-magnet, and the current of electricity in coil S, will greatly increase the force or influence upon needle *i* when so wound either to repel or retract the same, depending upon the manner of winding the coil, as is well understood.

L′ is a swinging lever or arm, which may also be pivoted at 2.

C is a cable or flexible connection which attaches the lower end of the lever L′, to the axle or hub of the wheel P², and also projects over the wheel 11, and supports the weight W.

B represents an electric battery, or any well-known means for generating a current of electricity.

B′ is a conductor connecting the arm *i*, to the junction 5; 5 being the junction between the coils of the electro-magnets M and M′.

6 is a return wire from the electro-magnet M′, and 7 is a return wire from the electro-magnet M.

M and M′ represent electro-magnets, each wound with coils, as shown. These electro-magnets may be constructed in any well-known form.

8 is a shaft for the friction gear-wheel F. The friction wheel F is provided with two friction surfaces or disks 9 and 10, and the friction wheel F is supported upon the shaft 8 by means of a key or spline which will allow F to have a longitudinal movement upon the shaft 8, but compel it always to revolve with the shaft.

G and G′ are gearings whereby the movement of the shaft 8 is conveyed to the shaft *a*. The shaft *a* extends downward, and is connected in any suitable manner with the gate so that the revolution of the shaft *a* in one direction opens the gate, and a counter

revolution shuts the gate. Any suitable attachment for opening and shutting the gate may be applied to the lower end of the shaft *a*.

II is a hand-wheel by means of which the shaft *a* may be operated by hand should the user ever so desire to operate it. The hand-wheel II may be dispensed with, however, without interfering with the operation of my invention.

b is a belt connecting shaft *a* to belt pulley P^2, which belt pulley is provided with a hub 15 upon which the flexible connection C is adapted to wind, as hereinafter described.

b' is the journal of the band wheel P^2, which journal may be supported in any suitable bearings. It is immaterial whether the journal *b'* revolves with the band pulley, or whether the band pulley revolves upon the journal.

In the drawing I have shown a belt *b* operated directly from the shaft *a*, but it is evident that the band wheel may be applied upon the shaft *a*, if desired.

W is a counter-weight adapted to return the lever L' to its normal position as the flexible connection C, is unwound from the hub 15.

P is a pulley upon a suitable shaft which is revolved by any suitable machinery. Upon the same shaft is also the friction pulley P', P and P' are rigid with the same shaft, and when P'' is brought in contact with the friction surface 9, it revolves the friction wheel F, in one direction, and when brought in contact with the friction surface 10, it revolves the wheel F, in another direction. The shifting of the wheel F, however, brings the friction surfaces alternately into contact with the pulley P'', the pulley P' having no shifting movement.

L is a lever armature adapted to turn upon the pivot O, as a fulcrum. What is shown to be the upper end of the lever L, engages with the circular groove 14, in the hub F, while the lower end of L acts as an armature for magnets M and M'.

W' is an adjusting weight placed upon an arm and preferably raised above the pivotal attaching point of the arm *i*. This weight W' is provided with a set-screw so that it may be raised and lowered and attached at any required point.

W^2 is an adjusting weight upon the arm *i*, which may be adjusted by means of a set-screw, or otherwise, to any required point.

12 represents the point of attachment for the flexible connection C, to the lower end of the lever L'.

I have described a connection between the arm *i*, and the operating parts which raise and lower the water-gate by means of a secondary battery B, and electro-magnets M' and M, which connection I deem to be the preferable form, but I do not wish to limit my invention to this form of connection; for the reason that the connection may be made directly between the arm *i*, and the mechanism which operates the shaft *a*, which shaft *a*, may be properly termed the gate-stem, in which case the secondary battery B, and magnets might be dispensed with, and the power derived from the electro-magnetic influence of the coil Z, be made to operate the opening and closing of the gate.

In the example of my invention shown and described in the drawing, the operation is as follows: When the electric current from the dynamo passes through the coil S, the arm *i*, is drawn into the coil S, until the projection 3, comes in contact with the tangent point C'. This allows the electric current from the battery B, to flow through the junction 5, through the coil wound around the magnet M', and thence back through the connection 6, across the contacts and back through B' to the battery, thus energizing the magnet M', and moving the armature or lower end of the lever L, toward its contact point with the magnet M'. L turning upon the pivot O, as a fulcrum moves the friction wheel F, on its shaft 8, until friction surface 10 comes in contact with P', the pulley P' revolving, then gives a revolving motion to F, and also conveys that revolution through gear-wheels G and G', to the shaft *a*, and the shaft *a*, being connected to the water-wheel, raises the gate, increasing the flow of water and thereby the amount of electricity generated by the dynamo up to the required amount. The belt *b*, revolves the pulley P', winding up the flexible connection C, its axle 15, drawing the lower end of the lever L', toward shaft *a*, thereby breaking the contact between C', and the projection 3. This will check the further opening of the gate at the point where the water, admitted upon the wheel or motor, is just sufficient to carry the required load or to impart the required energy to the dynamo. The breaking point should be where the arm or needle *i*, balances with relation to the coil S. If the current through the coil S, becomes too much weakened, the arm *i*, will swing back and projection 4, will come in contact with C^2, which will cause the electric current from the battery B, to circulate through the coil of magnet M, connecting conductor 7, thereby connecting points C^2 and 4, and connecting conductor B', back to the battery B. This will draw the armature L, toward the electro-magnet M, turning the armature lever L', on its fulcrum O, moving the friction wheel F, until friction surface 9, comes in contact with P'; P' revolving as above described will give a reverse action to the friction wheel F, and consequently through F, to shaft 8, gears G and G' and the shaft *a*, thereby reversing all the operating parts and shutting off the water from the water-wheel or motor so that only a proper amount of water will flow upon the wheel in order to carry the required load. It will be understood that the winding may be such that the action will be reversed, and the connection such that the reverse action will open the gate. Thus, the water supply for the wheel is always perfectly gaged by means

of the magnetic energy exerted through the coil Z, to the swinging arm or needle *i*. In case a heavy load is put upon the circuit suddenly, a slight lagging of speed sometimes happens, thus lowering the voltage of the current and lessening the amount of current which flows through the coil *n*. This allows the arm or needle *i*, to go farther into the coil or to swing farther toward the attracting point and thus opening the gate a little farther before the contacts break. This brings the speed quickly back to its normal position and corrects the voltage of the current. This is found desirable for the reason that water does not move as quickly or readily as steam or air, it having greater specific gravity and greater momentum. If the current is in large volume thrown off, a slight increase in speed and voltage may occur, thus increasing the current in coil *n*, thereby allowing the arm or needle *i*, to withdraw farther out of the coil than it would normally, thus closing the gate more than it would normally and thereby lowering the voltage to the proper point. In case the needle *i*, is so wound as to be repelled, the repulsion or reverse action of *i*, will produce the result last above described.

I have shown what I deem to be the most preferable method of applying the electro-magnetic force, generated by the electric current passing through the connections, from the dynamo, but any other suitable form may be applied, it being well-known that a current of electricity passing through any conductor will produce this electro-magnetic power, which power I desire to utilize for the purpose hereinafter specified.

Having thus described my invention, what I claim to have invented and desire to secure by Letters Patent, is—

1. In an electrical water wheel-governor, the combination of the dynamo conductor having a coil S, a pivoted arm or needle carrying two contacts, a pivoted oscillating arm carrying contacts adapted to engage the contacts carried by said arm or needle, suitable connections between said oscillating arm and the water wheel gate, a circuit breaking device actuated by the movement of the gate mechanism, and means for actuating the gate operating mechanism, substantially as described.

2. The combination of the coil S, and the coil *n*, a needle *i*, suitable connections between said needle and the gate of the water-wheel whereby the flow of water is automatically controlled through the magnetic energy exerted from the dynamo connections, substantially as described.

3. The combination of the coils S and *n*, the needle *i*, the swinging lever L′, the flexible connection C, pulley P^2 with its hub 15, the weight W, a battery, electro-magnets, conductors connecting said magnets and battery, circuit closing devices actuated by the needle for closing the circuit through either of said magnets, an armature actuated by said magnets, and gearing for actuating a water gate controlled by said armature, substantially as described.

4. The combination of the coils S and *n*, the needle provided with contact points for opening and closing the electric current, the battery B, the electro-magnets M′ and M, suitable coils thereon, connections between such coils and the battery, an armature as 11, shifting device as F, provided with friction disks 9 and 10, revolving pulley P′, and suitable mechanism connecting the shaft of F to the water-wheel, substantially as described.

5. The combination of the coil of the dynamo, a needle turning upon a pivot having contact points adapted to open and close an electric current, a battery as B, electro-magnets as M, M′, suitable conductors extending from said electro-magnets to said battery whereby the current may be directed through either one or the other of said electro-magnets at pleasure, a lever armature as 11, a shifting mechanism as F, operated by means of a pulley as P, suitable mechanism connecting said shifting mechanism F, with the gate of the water-wheel, a band as *b*, pulley P^2, lever L, flexible connection C and weight W, all constructed substantially as and for the purpose described.

In witness whereof I have hereunto set my hand and seal in the presence of two witnesses.

CARL S. ENGLISH. [L. S.]

Witnesses:
EDWARD TAGGART,
CHRISTOPHER HONDELINK.

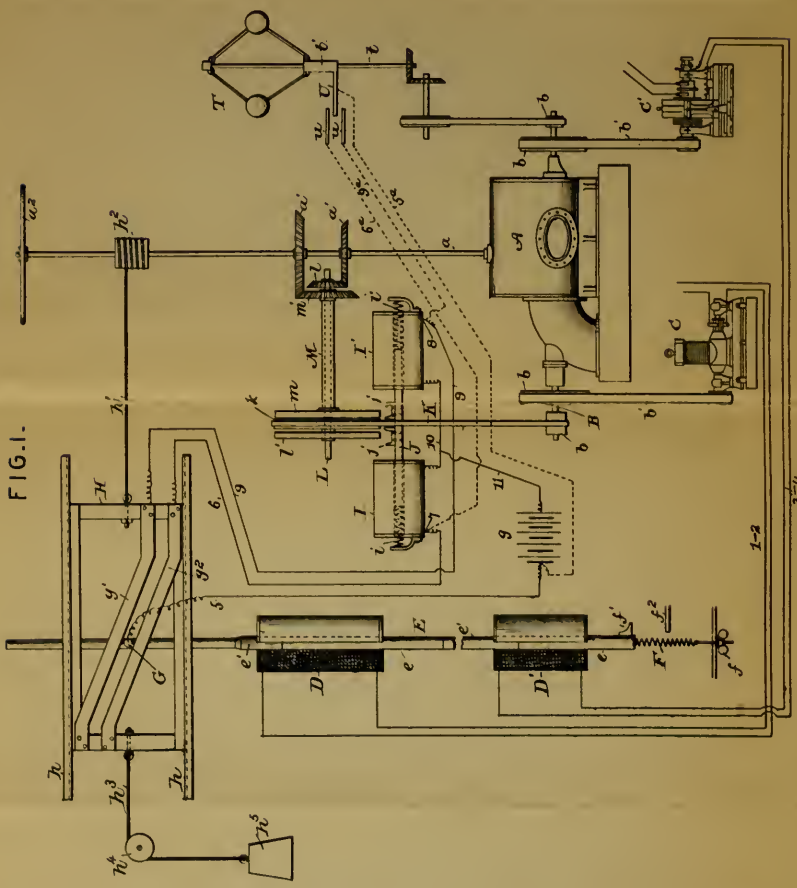
(No Model.) 2 Sheets—Sheet 1.

E. P. WETMORE.

ELECTRICAL WATER WHEEL GOVERNOR.

No. 519,597. Patented May 8, 1894.

FIG. 1.



Inventor

Earl P. Wetmore

Witnesses

Jas. K. McCathran

L. P. Hochauptle.

By his Attorneys.

C. A. Snow & Co.

(No Model.) 2 Sheets—Sheet 2.

E. P. WETMORE.

ELECTRICAL WATER WHEEL GOVERNOR.

No. 519,597. Patented May 8, 1894.

FIG. 4.

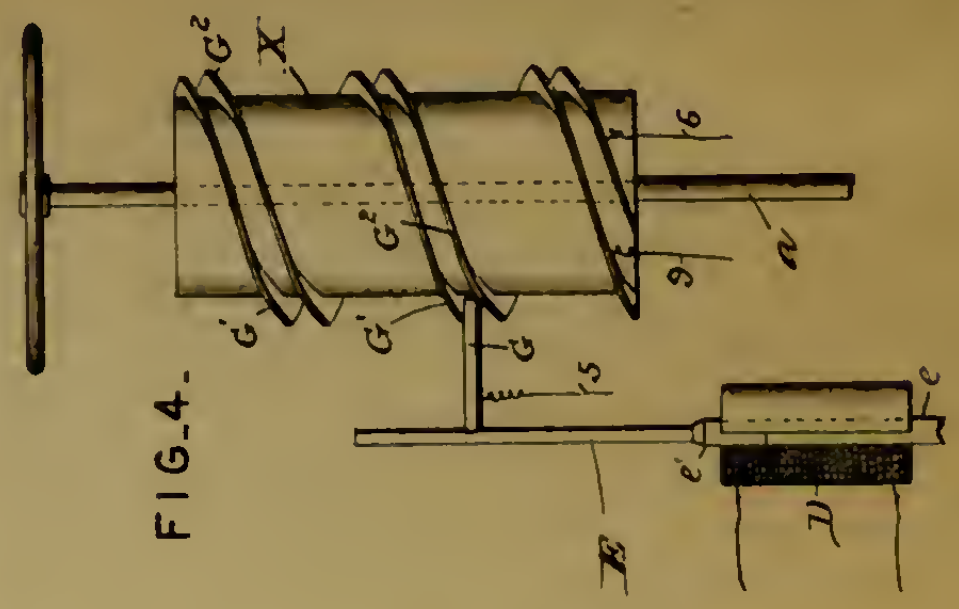


FIG. 2.

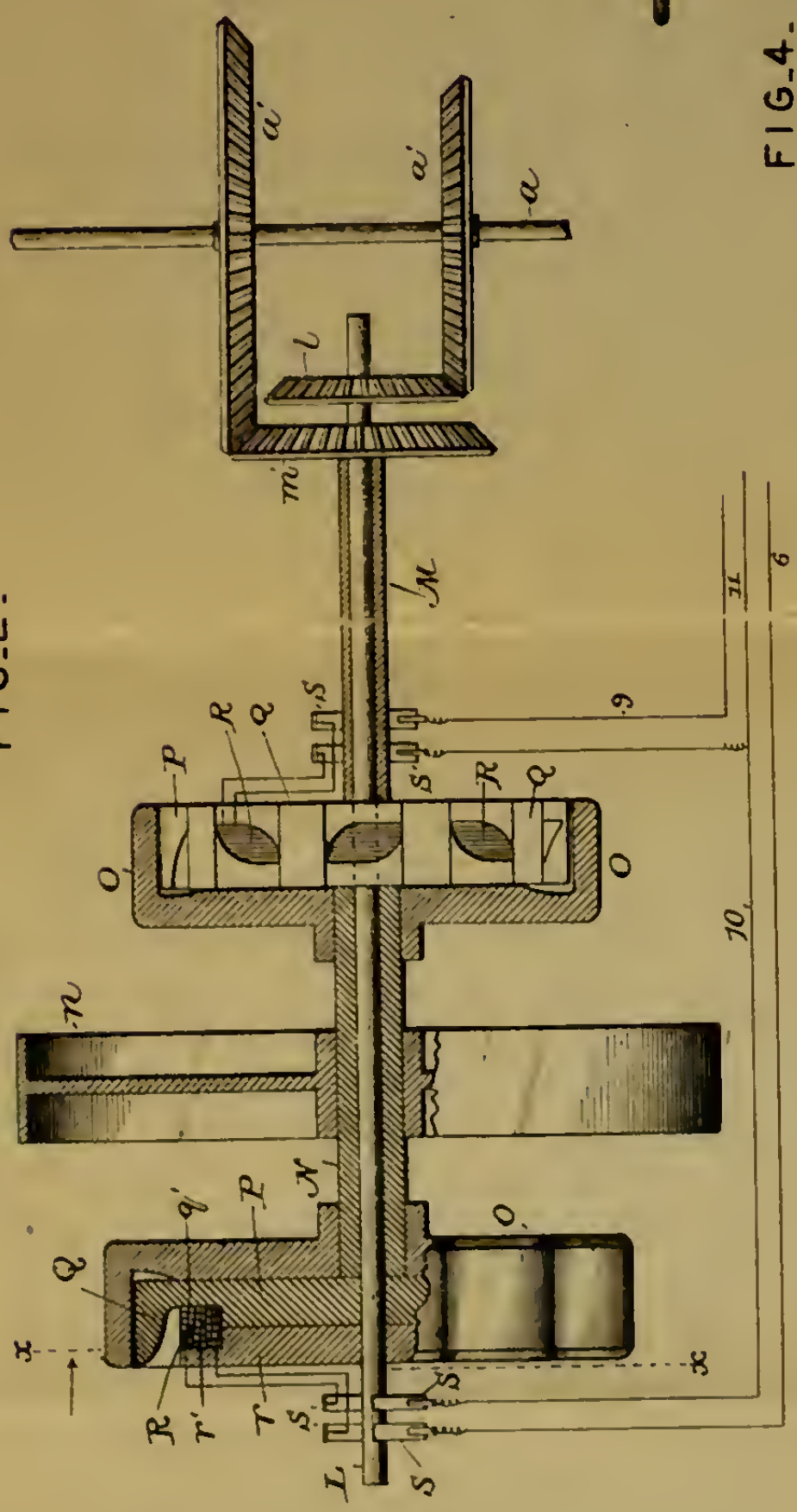


FIG. 3.

Inventor

Earl P. Wetmore

Witnesses

Jas. K. McCathran

D. Whitehead

By his Attorneys.

C. A. Snow & Co.

UNITED STATES PATENT OFFICE.

EARL PORTER WETMORE, OF HELENA, MONTANA.

ELECTRICAL WATER-WHEEL GOVERNOR.

SPECIFICATION forming part of Letters Patent No. 519,597, dated May 8, 1894.

Application filed January 16, 1894. Serial No. 497,083. (No model.)

To all whom it may concern:

Be it known that I, EARL PORTER WETMORE, a citizen of the United States, residing at Helena, in the county of Lewis and Clarke and State of Montana, have invented a new and useful Electrical Water-Wheel Governor, of which the following is a specification.

This invention relates to electrical water wheel governors; and it has for its object to provide improved governing devices of this character which shall automatically operate to control the speed of a water wheel according to the load upon the dynamo or dynamos in circuit with the governor, or more technically speaking, according to the variations in current strength or in the output of such dynamos.

The main object of the present invention, therefore, is to regulate the effective supply of water to the water wheel or wheels through means of valves, gates or deflecting nozzles, which are directly controlled by the change in the output of electric energy from the dynamos which are operated by the water wheel or wheels, in order to admit or cut off the supply of water in direct proportion to the increasement or decreasement of the load upon the electric generators.

It is well known, that where the fly ball or centrifugal governors, or differential speed governors, are used in connection with water wheels of the governor does not become effective until the speed of the water wheels is changed. This change of speed in the water wheels is directly caused by the change of load upon the dynamos, and this invention therefore prevents loss of time in effecting the regulation, inasmuch as the change of load upon the dynamos puts the governing devices herein described into practical operation.

With these and other objects in view which will readily appear as the nature of the invention is better understood, the same consists in the novel construction, combination and arrangement of parts hereinafter more fully described, illustrated and claimed.

In the accompanying drawings:—Figure 1 is a diagrammatic plan view of an electrical water wheel governor constructed in accordance with this invention. Fig. 2 is a detail elevation partly in section of electric clutches preferably used in connection with the apparatus shown in Fig. 1. Fig. 3 is a detail sectional view on the line x—x of Fig. 2. Fig. 4 is a detail view showing a preferred construction of contact device.

Referring to the accompanying drawings, A represents a single or double turbine water wheel, or reacting wheel of the Pelton or other type. This water wheel, as stated, is of any preferred construction, and the valve or gate mechanism thereof is controlled by means of the vertical valve rod or shaft a, which is provided at an intermediate point with reversely disposed beveled gear wheels a', and carries at its upper end a hand wheel a^2, which is ordinarily employed for controlling the flow of water through the wheel by hand, but in the present invention such rod is controlled automatically by the devices to be hereinafter described.

The shaft B, of the water wheel A, carries outside of the water wheel casing, any number of belt pulleys b, depending upon the number of electrical generators or dynamos driven by such water wheel, but as illustrated in Fig. 1. of the drawings, two of said belt pulleys receive the dynamo belts b', which are belted to dynamos C and C′, of any type or construction, the dynamo C, being illustrated as a direct current dynamo, while the dynamo C′, is of the alternating type, and it is to be understood that any number of dynamos of any type may be employed. The direct current dynamo C, is connected in series, by the series circuit 1—2 with a suitably arranged solenoid D, while the alternating dynamo C′, has the compound field winding thereof connected in series with the solenoid D′, by the series circuit 3—4.

The solenoid D, is illustrated as being arranged directly above and in line with the solenoid D′, and it will of course be understood that the specific character of the winding of said solenoids depends upon the fact whether each is connected with one or more dynamos and of the character of such dynamos. Should one or more of the dynamos operated by the water wheel be of the polyphase type, then the magnet D, would be included in series with the field circuit of the polyphase current dynamo, that is, the entire exciting current would pass through the magnet

D, and regulation would be effected since the exciting current of a polyphase generator varies in a certain ratio to the load upon the dynamos. In case one or more of the dynamos operated by the water wheels is of an arc or constant current type, then the magnets D or D′, would be made up of one or more sections of fine wire of proper resistance to enable the same to be connected directly across the terminals of the arc or constant current dynamo. These changes in the windings will of course be varied to accommodate the apparatus to the different dynamos, but only to secure the same result in connection with such dynamos as those illustrated in the drawings, and the aligned solenoids or magnets D, and D′, accommodate therein the sectional core plunger E. The sectional core plunger E, is made up of connecting magnetic metallic sections *e*, and non-magnetic metallic sections *e′*, which form together a single continuous core plunger, but it will of course be understood that the magnetic metallic portions *e*, of the core, are adapted to move within the solenoids, so that motion will be given to the core plunger in either direction, as such solenoids become energized or de-energized. The core plunger E, has connected with the lower end thereof the adjusting spring F, adjustably connected at *f*, to a suitable point of attachment, so that the core plunger will always be returned to its normal inactive position after either or both of the solenoids have become inactive, and said core plunger is further provided at its lower extremity with an off-standing stop arm *f′*, which is adapted to come in contact with an off-standing stop projection *f²*, which provides a limit to the downward movement of the plunger. As the said core plunger E, is moved in either direction according to the variation in the strength of either or both of the solenoids, as the load upon the dynamos connected therewith increases or decreases, such core plunger is adapted to act as a circuit closer for the valve or gate operating devices to be described, and is provided at a suitable point above the upper solenoid D, with a contact pin or roller G, which is electrically connected by the wire 5, with one pole of a convenient source of electrical energy *g*, which may be a suitable series of batteries or a dynamo. The contact point or roller G, carried by the solenoid-controlled core plunger E, is adapted to play between the approximately parallel contact plates *g′*, and *g²*, respectively. The contact plates *g′* and *g²*, are mounted in substantially parallel planes and at an angle on the sliding contact frame H. The sliding contact frame H, is mounted to slide between the parallel guides or ways *h*, and has attached to one end the adjusting rope *h′*, which winds and unwinds on the grooved rope drum *h²*, secured on the valve rod *a*, while to the other end of the sliding frame H, is attached one end of the weight rope *h³*, which passes over a suitably arranged guide pulley *h⁴*, and has attached to the free end a weight *h⁵*, which serves to slide the contact frame in one direction. The movement of the core plunger E, is adapted to bring the contact pin or roller G, in contact with either of the plates *g′* or *g²*, and complete a circuit through the external source of electrical energy *g*, and to provide for this, the contact plate *g²*, is electrically connected by the wire 6, to one terminal 7, of a suitably arranged solenoid I, directly in a line with which, and opposite to, is arranged a duplicate solenoid I′, one terminal 8, of which is connected by the wire 9, to the other contact plate *g′*, while the adjacent terminals of these two solenoids I and I′, are joined by the bridge wire 10, which has connected thereto the circuit return wire 11, leading to the other pole of the external source of electrical energy *g*, and thereby providing for a completion of the external circuit through either of the magnets I and I′, according as the contact pin or roller G, is moved in contact with either of the contact plates *g′*, or *g²*, mounted on the sliding frame H. The aligned solenoids I and I′, are adapted to control, in either direction, the movement of a horizontally moving core J, the ends of which slide in the opposite solenoids, and within the open outer ends of the solenoids I, and I′, are arranged the core adjusting springs *i* and *i′*, which have one end thereof bearing on the extremities of the core J, and are of a tension which holds the said core to a normal inactive position. The horizontally moving core J, carries at a point between the inner adjacent ends of the solenoids I and I′, the parallel shifting lugs or tappets *j*, which embrace a belt K, driven from one of the pulleys *b*, of the water wheel shaft, and passing over a loose pulley *k*, mounted loosely on a suitably supported and arranged regulating shaft L, which carries at one end a pinion *l*, meshing with the lower one of the wheels *a′*, and adapted to turn such wheel in a direction to close or cut off the supply of water controlled by the rod *a*. The shaft L, carries at a point alongside of the intermediate loose pulley *k*, a fast pulley *l′*, onto which the belt is adapted to be moved by the magnet shifting devices when the core J, is shifted in one direction. At the opposite side of the pulley *k*, and loosely mounted on the shaft L, is the sleeve M, carrying at one end alongside of the loose pulley a belt wheel *m*, and at its opposite extremity a beveled gear wheel *m′*, which meshes with the upper one of the beveled gear wheels *a′*, and is adapted to turn the valve or gate regulating rod *a*, in a direction to open the valve or gate of the water wheel.

The operation of the apparatus set up as just described is as follows:—Assuming direct current and alternating dynamos C and C′, are in operation from the water wheel A, a sudden increase of current load on the direct current dynamo C will energize the solenoid D, sufficiently, so as to move the core plunger E, upward, against the tension of the

spring F, and cause the contact pin or roller G, to contact with the upper metallic contact plate g', on the sliding frame. The circuit is then completed through the wire 5, from the external source of generation g, the contact plate g', wire 9, solenoid I, and the return wire 11, which circuit energizes the solenoid I', and moves the shifting core J, in a direction which shifts the belt K, from the loose pulley, k—, onto the sleeve pulley m, which immediately operates the gear m', and the upper one of the rod gears a', so as to immediately increase the supply of water. As soon as the valve rod or shaft a, commences to turn, the adjusting rope h' winds on the drum h^2, and draws the frame H, in one direction until such frame has moved sufficiently far to relieve the contact G, from the upper contact plate g'. The current is thus automatically broken so as to de-energize the magnet I', and then the spring i', immediately moves the core J, into a normal position and shifts the belt K, back onto the loose pulley. The two contact strips or plates g' and g^2, and the drum h^2, are so adjusted that the valves or gates are opened a proper amount to admit the required water for the operation of the wheels when the contact G touches neither of such plates, and therefore the distance or space between such contact plates determines the sensitiveness of the governor or regulator. It will be obvious that similar increases on the load of the alternator C', would have a similar effect on the solenoid or magnet D', to secure the same regulation just described; while, conversely, a decrease in the load of either dynamo would have the opposite effect, that is, to decrease the supply of water to the water wheel, in such case the sliding frame H, being moved properly in one direction by the weighted rope h^5.

While I have illustrated and described a belt shifting device which controls the separate gears engaging the gears on the valve rod or shaft, I preferably substitute these devices by the clutch devices or clutch wheels shown in Figs. 2 and 3 of the drawings. In Fig. 2, the shaft L, carries the gear l, at one end, and the shaft sleeve M, carries the gear m', at one end in the same arrangement as described in connection with the belt shifting devices, but in the preferred arrangement, the shaft L, accommodates thereon a drive sleeve N, to which is keyed a belt wheel n, driven by the belt K, and to the opposite extremities of this sleeve are secured the metallic cup disks O, inside of which are adapted to turn the magnet wheels P. One of the magnet wheels P, is fastened to the shaft L, and the other of such wheels is fastened to one end of the sleeve M, in a similar manner to the mounting of the pulleys l' and m. Both of said magnet wheels P, are sectional and each is provided with a circumferential series of projecting pole pieces Q, adapted to align with similar inwardly projecting pole projections q, formed on the inner periphery of the cup disks. At one side of each magnet wheel and inside of the circle of the pole pieces such magnet wheels are provided with the coil recesses q' in which are placed the magnet coils R, secured in position by the cap plates r, having inner recessed edges r', forming a portion of the coil recesses. The terminals of the magnet coils R, lead respectively to collecting and discharging rings S, S, arranged at one side of the said magnet wheels. The same wire connections are employed in connection with the clutch wheels just described as in connection with the solenoids I and I', the wire 6 from the plate g^2, leading to the collecting ring of one magnet wheel, the wire 9, from the plate g', leading to the collecting ring of the other magnet wheel, the bridge wire 10, connecting the discharging rings of both magnet wheels, and the return wire 11 connected to the bridge wire 10.

When the circuit is closed by the moving contact G, in the manner already described with either one of the contact plates on the sliding frame, either one or the other of the magnet wheels is energized so that the poles thereof are alternately north and south, and necessarily hold the pole projections q, magnetically attracted thereby, so that as the sleeve N, rotates, and turns the cup disks, the energized magnet wheel will be caused to revolve and turn the beveled gear wheel connected therewith, in a similar manner to the belt shifting operation already described.

In connection with the belt shifting or clutch wheel devices just described, I may employ an ordinary centrifugal or fly-ball governor T, the shaft t, of which is geared with and driven from the water wheel shaft B, and the sliding collar t', which is moved up and down by the balls, is provided with a moving contact arm U, corresponding to the contact G and connected by the dotted wire 5^a, with one pole of the generator g. The moving contact U, is arranged to play between the separate contacts u, corresponding to the plates g', and g^2, and are connected by the wires 6^a, and 9^a, with the same connections as the wires 6 and 9. The moving of the contact U, in contact with either one of the contacts u, secures the same operation from the belt shifting devices or clutch wheels as previously described.

Changes in the form, proportion and the minor details of construction may be resorted to without departing from the principle or sacrificing any of the advantages of this invention, and at this point attention is directed to the fact that in the foregoing description I have shown and described the frame H, upon which the contact strips g' and g^2, are located and which is suitably controlled by the drum h^2, rope and counterweight, for simplicity in explaining the operation of the apparatus, but ordinarily and preferably the contact strips g', and g^2, would be arranged in the same relation to each other upon a drum or cylindrical frame X, mounted di-

rectly upon the shaft a, of the valve or gate mechanism as clearly shown in Fig. 4, of the drawings, thereby avoiding the use of the connecting devices.

By reference to Fig. 4, it will be seen that the contact plates which are lettered G′ and G², to correspond with those on the sliding frame H, are arranged spirally on the cylindrical frame X, and are disposed parallel with each other so as to correspond in every particular to the relative arrangement of the plates g' and g^2, on the said sliding frame so that the same operation will be effected as the contact pin or roller G, is moved against either of the plates by the core, plunger, or armature E. The same circuit connections are observed in this preferable form of contact device it being shown that the wire 5, is connected to the contact G, the wire 6, to the contact plate G², and the wire 9, to the plate G′, and it is thought that the operation of this construction will be readily apparent without further description.

Having thus described the invention, what is claimed, and desired to be secured by Letters Patent, is—

1. In an electrical water wheel governor, the combination with the water wheel, the water wheel valve rod or shaft, and the dynamo driven by the water wheel; of electrically controlled gear devices connected with the valve rod or shaft, an automatically moving contact frame controlled by the movements of the valve rod or shaft and carrying spaced contact plates in circuit with said gear devices, a solenoid included in the dynamo circuit, a core, plunger, or armature controlled by the solenoid and having a contact arranged to move between said contact plates, and an external source of electrical energy included in a circuit with said contact and said electrically controlled gear devices, substantially as set forth.

2. The combination with a prime mover, its valve or regulating mechanism and the dynamos driven by the prime mover; of electrically controlled gear devices connected with the valve or regulating mechanism and in circuit with an external source of electrical energy, an automatically moving contact frame carrying spaced contact plates in circuit with said gear devices, solenoids circuited with the dynamos, a core, plunger or armature controlled by said solenoids and provided with a contact point or roller playing between the contact plates and also connected with said external source of electrical energy, substantially as set forth.

3. In an electrical water wheel governor, the combination with the water wheel valve rod or shaft; of electric motor device geared to said shaft to turn the same in either direction and included in a circuit with an external source of electrical energy, an automatically turning frame or cylinder carrying spaced contact plates arranged at an angle and separately connected by wires with said motor devices, and an automatically controlled contact point or roller playing between said contact plates and electrically connected with a convenient external source of electrical energy, substantially as set forth.

4. In an apparatus of the class described, the combination with the electrically controlled gearing devices, a similarly controlled moving contact included in the circuit of said devices, and an external source of electrical energy; of a prime mover valve shaft or rod geared to said gear devices, a drum or cylinder mounted on said shaft or rod and turning therewith, and parallel contact plates secured spirally on said drum and adapted to have said moving contact play there-between, substantially as set forth.

5. In an electrical water wheel governor, the combination with the water wheel, its valve mechanism and the dynamo driven by the water wheel; of electrically controlled gear devices connected with the valve mechanism, spaced contact plates suitably arranged and controlled by the movement of the valve mechanism shaft, a solenoid included in the dynamo circuit, a core, plunger, or armature, controlled by said solenoid and having a contact moving between said contact plates, and an external source of electrical energy included in a circuit with said contact and the valve controlling devices, substantially as set forth.

6. In an electrical water wheel governor, the combination with the water wheel, its valve or gate mechanism, electric motor devices geared with said valve or gate mechanism, automatic circuit devices having a moving contact, and controlled by the dynamos driven by the wheels; of suitably arranged solenoids circuited separately with a dynamo and energized and de-energized according to the fluctuations in current strength generated thereby, and a sectional core plunger, having magnetic metallic portions moving in each of the solenoids and connected to and controlling the moving contact of the circuit closing device, substantially as set forth.

7. In an electrical water wheel governor, the combination with the water wheel, its valve or gate mechanism and the dynamos driven thereby; of electric motor devices geared with said valve or gate mechanism and included in the circuit of the external source of electrical energy, a drum or cylindrical frame mounted on the shaft of the valve mechanism, parallel contact plates mounted on said drum or frame and separately connected to reverse operating portions of said electric motor devices, electrically aligned solenoids circuited separately with the dynamos driven by the water wheel, and a core plunger moving in said aligned solenoids and having a contact playing between said contact plates and electrically connected with the external source of electrical energy, substantially as set forth.

8. In an electrical water wheel governor, the combination with the water wheel valve rod

or shaft having reversely disposed gear wheels, separate shafts having gear-wheels meshing respectively with different ones of the gears on the valve rod or shaft, electro-magnetic clutches or clutch wheels mounted on said separate shafts, and electrically controlled circuit closing devices included in separate circuits with said clutches or wheels to energize the same separately, substantially as set forth.

9. In an electric water wheel governor, the water wheel valve rod or shaft having reversely disposed gear wheels, a suitably arranged shaft carrying at one end a gear wheel meshing with one of the wheels on the rod or shaft, a shaft sleeve mounted on one end of said suitably arranged shaft and carrying on one end a gear wheel meshing with the other one of the wheels on the valve rod or shaft, magnet wheels mounted on said suitably arranged shaft and on one end of the shaft sleeve, a drive sleeve mounted on said suitably arranged shaft and driven from the water wheel, metallic cup disks secured on the ends of said drive sleeve and surrounding the magnet wheels, electrically controlled circuit closing devices, and separate circuit connections from the circuit closing devices to each of the magnet wheels to energize the same separately, substantially as set forth.

10. In an apparatus of the class described, the combination with the separate shafts; of a metallic cup disk mounted on one of said shafts, a magnet wheel mounted on the other one of the shafts inside of the cup disk and having a circumferential series of projecting pole pieces and an energizing magnet coil clamped inside of the same and inside of the circle of the pole pieces, and suitable circuit connections with the magnet coil, substantially as set forth.

In testimony that I claim the foregoing as my own I have hereto affixed my signature in the presence of two witnesses.

EARL PORTER WETMORE.

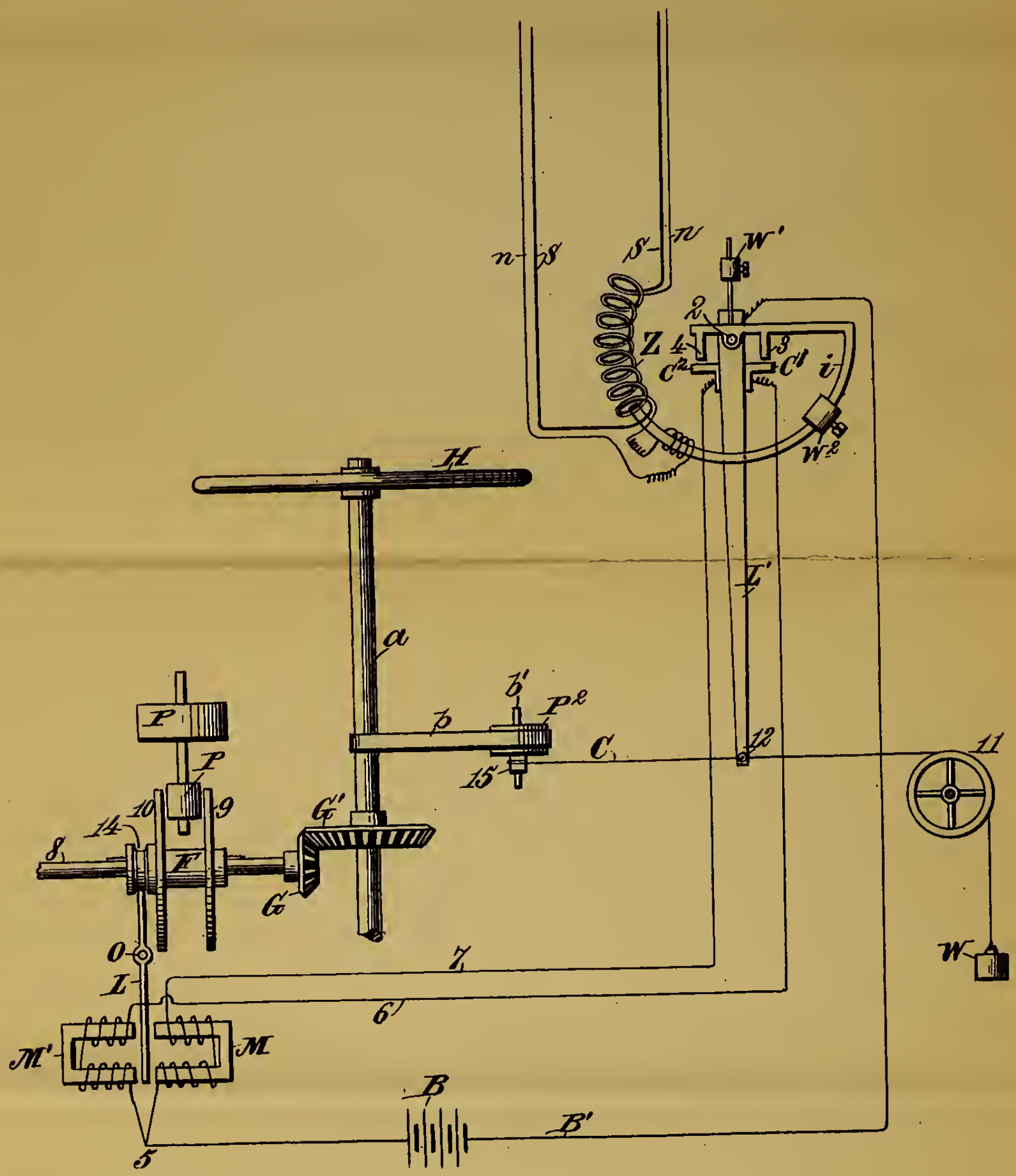
Witnesses:
H. S. HEPNER,
C. H. ALEXANDER.

(No Model.)

C. S. ENGLISH.

ELECTRICAL GOVERNOR FOR WATER WHEELS.

No. 521,085. Patented June 5, 1894.



Witnesses.
Robert Everett.
G. W. Rea.

Inventor:
Carl S. English.
By
Edward Taggart.
Atty.

(No Model.)

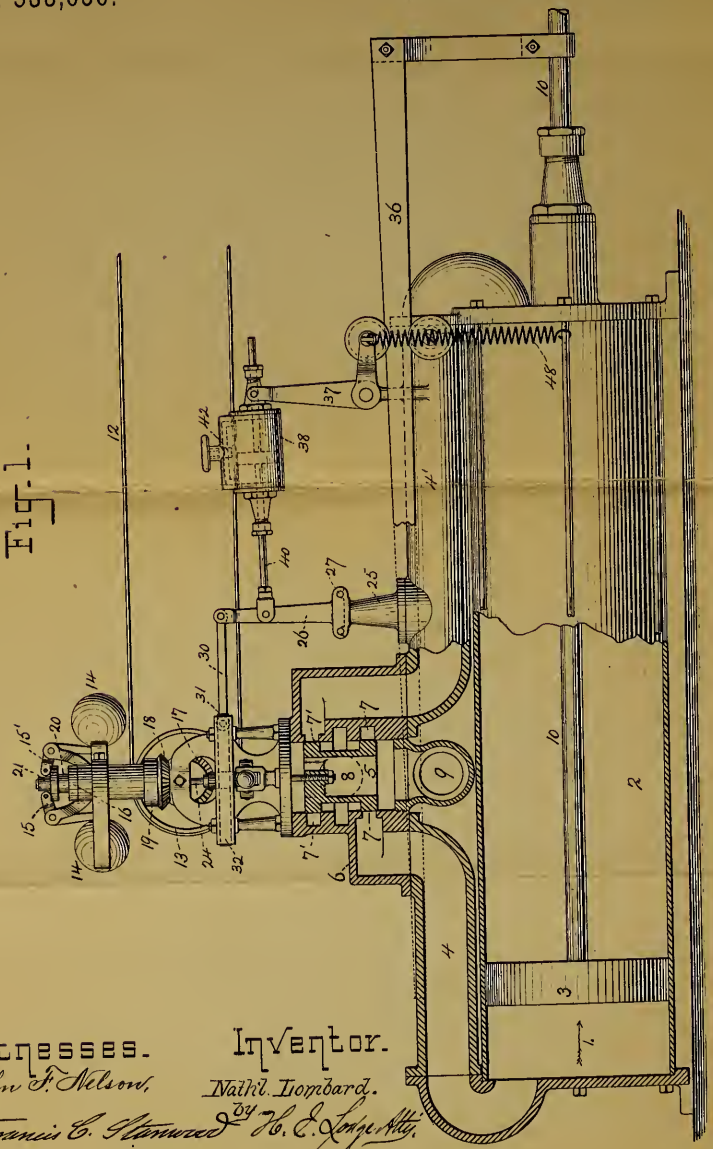
2 Sheets—Sheet 1.

N. LOMBARD.

SPEED REGULATOR.

No. 533,656. Patented Feb. 5, 1895.

Fig. 1.



Witnesses.
John F. Nelson.
Francis C. Stanwood

Inventor.
Nathl. Lombard.
by H. C. Lodge Atty.

(No Model.) 2 Sheets—Sheet 2.

N. LOMBARD.

SPEED REGULATOR.

No. 533,656. Patented Feb. 5, 1895.

Fig. 2.

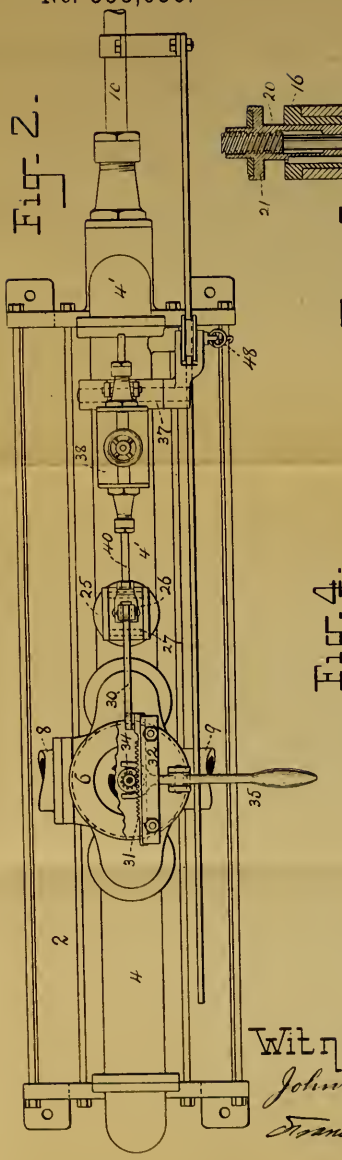


Fig. 3.

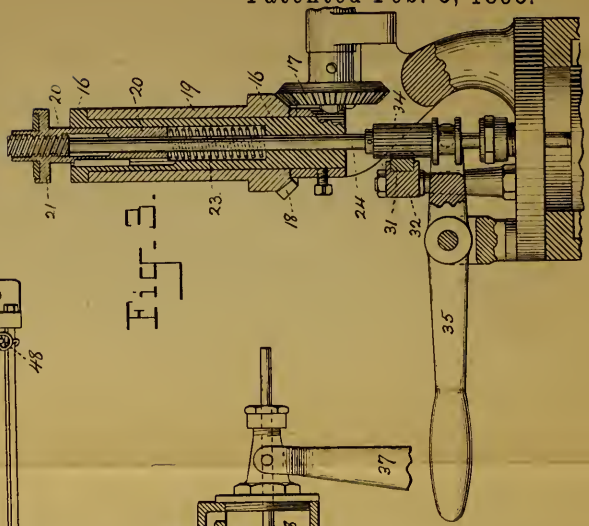
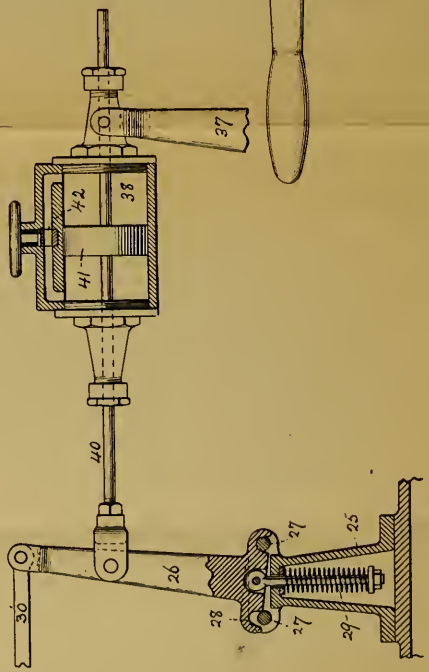


Fig. 4.



Witnesses.

John F. Nelson.

Francis E. Stanwood

Inventor.

Nathaniel Lombard.

By H. E. Lodge Atty.

UNITED STATES PATENT OFFICE.

NATHANIEL LOMBARD, OF BOSTON, MASSACHUSETTS, ASSIGNOR TO THE LOMBARD WATER WHEEL GOVERNOR COMPANY, OF SAME PLACE.

SPEED-REGULATOR.

SPECIFICATION forming part of Letters Patent No. 533,656, dated February 5, 1895.

Application filed August 14, 1894. Serial No. 520,258. (No model.)

To all whom it may concern:

Be it known that I, NATHANIEL LOMBARD, a citizen of the United States, residing at Boston, in the county of Suffolk and State of Massachusetts, have invented certain new and useful Improvements in Speed-Regulators; and I do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same, reference being had to the accompanying drawings, and to figures of reference marked thereon, which form a part of this specification.

This invention relates to improvements in speed regulators, particularly that class operated by centrifugal action upon revolving weights. It is a well known fact that in regulators of this class there is a tendency to continued changes due to various agencies, as the amount of work, steam pressure, or other incidental causes. As these changes require more or less motive power in the form of steam, water or gases, the valve which admits such and is controlled by the speed regulator is being incessantly shifted. In consequence of these changes very frequently continual variations in speed occur due to the excessive diminution or increase of the fluid agency—that is, if a change in the main valve is made, the period during which the valve is opened or closed is too long. As a result in the event of the speed falling below the normal the regulator causes the valve to open, and this latter in lieu of being opened a certain amount and then stopped continues to open. The result is that the speed increases until the normal is not only reached, but very often exceeded, when the weights again operate to partially close the valve, and perhaps reduce the speed too much. However this may be, the general effects of the present and most approved speed regulators are to keep the apparatus fluctuating constantly. This tends to maintain the speed not at a steady normal rate, but either too fast or too slow.

The purpose and object of my invention is to endeavor to preserve the speed at a normal, and when the main valve which admits the actuating medium is shifted by the action of the weights, to produce a change, certain mechanism is put into activity to operate a secondary valve, which checks the movement of the main valve before the full effects of the change in the said main valve upon the motion is fully felt; hence excessive variations cannot take place. If, as before instanced, the speed is below the normal the weight opens the main valve which is very soon stopped; the full amount of gate demanded by the balls not being used. If this is not sufficient the weights again operate and these acts are repeated, the main valve which admits the power, as steam or water, being successively changed until the desired degree of opening or closing is attained.

My present improvements relate to that class of speed regulators in which the main gate or valve supplying the medium, as steam, water or gas, is held in position or changed, as circumstances may require, by means of a piston adapted to reciprocate within a fluid-filled cylinder, the fluid in the latter being allowed to circulate from end to end, and by such circulation to permit movements of the piston. This circulation is regulated by means of a secondary valve under the control of the speed regulator weights, and normally said valve is closed over both inlet and outlet ports by which means the main gate is held locked fast and prevented from moving.

My invention is embodied as before premised in mechanism which operates to bring the secondary valve or that which regulates the circulation of liquid within the closed cylinder to a fixed predetermined position and so maintains it. This secondary valve however is free to be shifted by the action of the regulator weights, and such shifts or changes cause the piston to move within the cylinder; but the mechanism which I consider as novel is intended to return the secondary valve at once or very shortly thereafter to its normal or closed position after it has been shifted or opened by the regulator weights, and also to allow return of the weights to their proper place, and which departure necessitated more or less movement of the main valve, without disturbing the position of the secondary valve. In brief this mechanism comprises a stationary post adapted to rock and to which is attached two oppositely disposed rods, one

equipped with a piston contained within a brake cylinder for air or fluid. The other rod terminates in a rack, which engages a pinion fast about the secondary valve rod. Thus this valve is adapted to be opened by the regulator weights, while the travel of the piston in the main cylinder serves to reciprocate a tapered bar, which rocks a bell-crank lever and tilts the post to close the secondary valve. The time during which the post is inclined from the vertical is intended to allow the weights to shift their position commensurate with the change in the speed due to the movement of the secondary valve without changing the said valve from its normal closed position.

The other peculiar features and the method of operating the various parts which co-operate to produce the object to be attained under my invention will be hereinafter fully set forth and explained.

The drawings represent in Figure 1 a longitudinal sectional elevation of a speed regulator equipped with mechanism embodying my invention. Fig. 2 is a plan. Fig. 3 is a vertical central sectional elevation in part of the regulator proper, and secondary valve-stem, and transversely of the main cylinder. Fig. 4 is an enlarged view of the rocking post and the secondary cylinder which serves as the resistance to the movement of said post.

In said drawings I have shown a closed cylinder 2 liquid-filled and adapted to contain a piston 3 which is capable of movement therein only as the liquid circulates from one side of said piston to the other. This is effected by means of two pipes 4. 4′. which connect with a valve 5 termed the secondary valve. This valve is located within a casing 6 and contains the feed parts 7.7′. respectively for the pipes 4.4′. as likewise a common discharge 8. The supply pipe is at 9, while a rod 10 interconnects the piston with the main gate or valve, not shown, which admits the active medium as steam, water or gas to the prime motor.

A belt 12 to the pulley 13 serves to rotate a pair of centrifugal weights or balls 14. These latter are supported on levers 15. 15′. which are mounted upon a fixed upright 16. Rotation of the balls is created by means of the toothed wheel 17 which meshes with another 18 affixed to the lower end of a sleeve 19 secured to the upright. A flanged tube 20 is placed within the upright standard and is constructed to reciprocate, but not to rotate by aid of a spline and groove connection. The flange 21 bears against the inner ends of the ball levers, while a spring 23 maintains these parts in contact.

Centrally of the standard is located the rod or stem 24 of the secondary valve. The upper end of this valve-stem or rod 24 is screw-threaded and engages the bore of the tube 20. Hence it will be understood that the flanged tube 20 is adapted to move up and down according to the changes in the position of the balls due to varying speed in the rotation of the sleeve 19. Such reciprocations likewise carry the valve 5 and valve-rod 24 and serve to open the valve wholly or in part, according to the amount of change in the speed; but when circulation takes place in the cylinder 2 the piston 3 is advanced and such movement is accompanied by rotation of the valve-stem. This latter act serves to close the secondary valve without further change in the position of the balls. Immediately after such closing of this valve the balls begin to move again in order to resume the position they held prior to this change in the gate which has just been effected, this movement of the balls being occasioned by the prime motor now influenced by this change of gate. To prevent the secondary valve being actuated by such movement of the balls and to retain the valve closed at times and again to allow it to be opened at other times is one of the important features of my invention which I shall now proceed to describe.

To effect rotation of the valve stem 24 at proper times and to cause the operating mechanism to quickly close the valve I have employed the following group of instrumentalities: Upon the top of the pipe 4′ for compactness of form is secured a hollow block or pedestal 25 which is capped to receive the base of a rocking post 26. The manner of uniting these two pieces is very simple and consists in the present instance of two transverse pins 27, which enter corresponding grooves 28 in the base of the post, while centrally is a pivotal rod 29 which is pendent from the base but within the pedestal and is spring-actuated. The tension of this spring is such that the post always tends to assume the vertical whichever way it is inclined from a normal. At the free or top end of this rocking post is positioned a bar 30 which interconnects said post with a toothed rack 31 suitably supported in a horizontal-guide block 32, while a pinion 34 is affixed about the valve-stem 24. This pinion is of considerable length, see Fig. 3, in order that the valve and valve-rod may be raised or lowered, when the valve is given longitudinal movement without causing the rack and pinion to disengage. A hand lever 35 may be attached in order that manual operation of the secondary valve may be effected if circumstances require. Furthermore to cause the rotation of the valve-stem which results in sliding of the secondary valve to close and to render this act directly dependent upon the travel of the piston 3, the following elements are provided: In parallelism with the piston rod 10 and attached thereto and moving with it is a tapered bar 36 which serves to oscillate a bell lever 37 fastened to the cylinder 2. One arm of this is equipped with an antifriction roller which co-operates with a similar roller on the cylinder, while the tapered bar 36 slides therebetween. A spring 48 maintains constant contact between the bell lever and the bar in or-

der to render the latter active should it move in either direction. The upper end of the opposite bell-lever arm is pivotally fastened to a cylinder 38 which serves as a brake or retarder and prevents the too quick return of the rocking post to the vertical, this return being varied by means of liquid or air confined within the cylinder 38. From the rocking post extends a rod 40 which passes through the cylinder, while a piston 41 affixed upon said rod is permitted movement within the cylinder according as the position of a valve 42, operated externally, allows more or less free circulation of the contents between opposite ends of the cylinder. It will be observed that the rod 40 is oppositely attached to the post from that of the bar 30.

The operation and correlation of the various groups of elements hereinbefore described are as follows: it being understood that the secondary valve is to stand normally closed irrespective of the variable positions of the balls. Hence, as before stated, the secondary valve is to be opened by the balls to advance the piston 3 one way or the other, but this shift of the valve is but temporary for the reason that the very act of moving said piston 3 serves to operate to close the valve quickly, but likewise causes said valve to remain closed during subsequent movement and return of the balls to their proper position, and which return has been produced by the change in the main gate just effected. With these premises, it will be seen that the piston 3 is now held stationary, and the main gate (not shown) at the end of the rod 10 positively locked because the valve 5 is shut and no circulation occurs in the cylinder 2. Upon this assumption and that the various parts are now operating normally, when an extra burden is assumed by the prime motor this calls for more main gate. At this moment the ball drop slightly and raise the flanged sleeve 19, see Fig. 3, carrying up the valve-stem and valve 5 which now allows fluid to enter the pipe 4 and advances the piston 3 in direction of arrow 1 to open the main gate; but to prevent excessive results from this opening of the main gate, the tapered bar 36 is withdrawn from beneath the bell-lever 37, when the spring 48 rocks said lever to the right and simultaneously tilts the post 26 likewise to the right since the rapid action of the spring causes the contents in the brake cylinder to serve as a solid body. This tilting of the post to the right also causes the rack to revolve its pinion and the valve 5 is immediately closed by the rotation of its valve stem, the flanged tube being a stationary or fixed point. It is evident that with a change in the gate, as instanced, the speed of the prime motor will be accelerated and the balls now below their normal position will tend to rise and resume their proper place. This act would again rotate the valve rod and actuate the valve. Hence to keep said valve closed during the return of the balls, the post is retarded more or less as it returns to the vertical, since it is this latter act which serves to prevent movement of the valve from its seat, the valve being rotated slowly to maintain a constant position and to counteract the effect which otherwise would be produced by the movement of the balls. This spring mounted post 26 now moves back slowly as the liquid or air in the brake cylinder flows through the valve 42. When said post has again assumed the vertical reverse rotation of the valve-stem 24 has taken place to compensate for the movement of the balls to their proper position and the valve 5 is maintained closed during such act.

From the above description it will be understood that the return of the tilting post to the vertical is intended to counteract the return of the weights to their proper position, the deviation of said weights from such position necessitating a change in the main gate. Hence this movement of the post is intended to be slow, as the balls ordinarily are not suddenly influenced by the main gate. It will be further understood that when the post is at the vertical, then movement of the balls in either direction will open the secondary valve. On the other hand the departure of the rocking post from the vertical caused by the movement of the weights will serve to close the valve.

What I claim is—

1. The combination with a centrifugal regulator, a fluid-filled cylinder, and a piston therein which controls a main valve for some prime motor, of a regulator valve adapted to control the travel of the piston, mechanism operated by movement of the piston to close the valve, and means to counteract the functions of the balls in the act of resuming their normal position to prevent the valve being operated, substantially as specified.

2. The combination with a centrifugal regulator, a main valve, a fluid-filled cylinder, and a piston operating the said valve, of a regulator valve for the piston, and mechanism interconnecting said regulator valve and piston and adapted to neutralize at certain times the functions of the regulator weights to move said valve, substantially as and for purposes explained.

3. In combination with a centrifugal regulator, a fluid-filled cylinder, and a piston therefor, a secondary valve to control circulation in said cylinder, and a rocking post operated by the piston to regulate the movements of the valve, substantially as set forth.

4. A centrifugal regulator, a fluid-filled cylinder, its piston, and a valve operated by the regulator, combined with a rocking post, mechanism from the post to the valve, as likewise means to actuate the post by travel of the piston, substantially as stated.

5. In speed regulators having centrifugal weights, a liquid-tight cylinder, a piston therein, a valve to regulate travel of the piston, combined with mechanism operated by the regulator to shift the valve in right line move-

ment without rotation, as likewise means by which to unite the piston with the valve and impart rotation and slide said valve endwise, substantially as specified.

6. In combination with a centrifugal speed regulator, a fluid-filled cylinder, its piston, and a valve to control circulation, of a valve rod united with said regulator for right line sliding travel, a rocking post, a rack and pinion to rotate at times said valve rod to slide the valve, and mechanism to interconnect the post with the piston, substantially as set forth.

7. In regulators, a rotary sleeve, centrifugal weights thereupon, a flanged tube reciprocated by said weights, combined with a valve, a valve rod longitudinally of the flanged tube, connections between the valve rod and tube to permit independent rotation of the rod means for producing rotation of said rod, and a piston controlled within a cylinder by the movements of the valve, substantially as described.

8. In combination with a cylinder, its piston, a valve to control the travel of said piston, a rocking post, and mechanism to operate the valve upon tilting of the post, a bar affixed to the piston, a lever to tilt the post, and brake mechanism to regulate the return of the post to a normal, substantially as specified.

9. The combination with a fluid-filled cylinder, a piston, its piston rod, an actuating bar, and a bell lever operated by the bar, of a rocking post adapted to stand upright a regulator valve operated thereby, means to incline the post from the vertical, and brake mechanism to regulate the return of the post to an upright position, as stated.

10. The combination with a fluid-filled cylinder, its piston, a brake cylinder, and a regulator valve adapted to slide endwise upon movement of the piston, of a tilting post, a rack and pinion united with said post to rotate the regulator valve, and a bell-lever likewise connected with said post and actuated by the travel of the piston, substantially as explained.

11. In regulators a cylinder, its piston, a regulator valve, and a reciprocating rod, attached to said valve, combined with a fixed standard, a tilting post adapted to stand upright therenpon, a bell-lever, and a bar affixed to the piston rod for actuating the said lever, a piston-equipped rod 41 pivotally secured to the post, a brake cylinder secured to the bell-lever, and means to regulate the travel of the brake piston by which to control the return of the post to a normal, substantially for purposes specified.

In testimony whereof I affix my signature in presence of two witnesses.

NATHANIEL LOMBARD.

Witnesses:
H. E. LODGE,
FRANCIS C. STANWOOD.

No. 695,220. Patented Mar. 11, 1902.

L. LYNDON.

ELECTROMECHANICAL WATER WHEEL GOVERNOR.

(Application filed Sept. 13, 1900.)

(No Model.) 4 Sheets—Sheet 1.

Fig. 1.

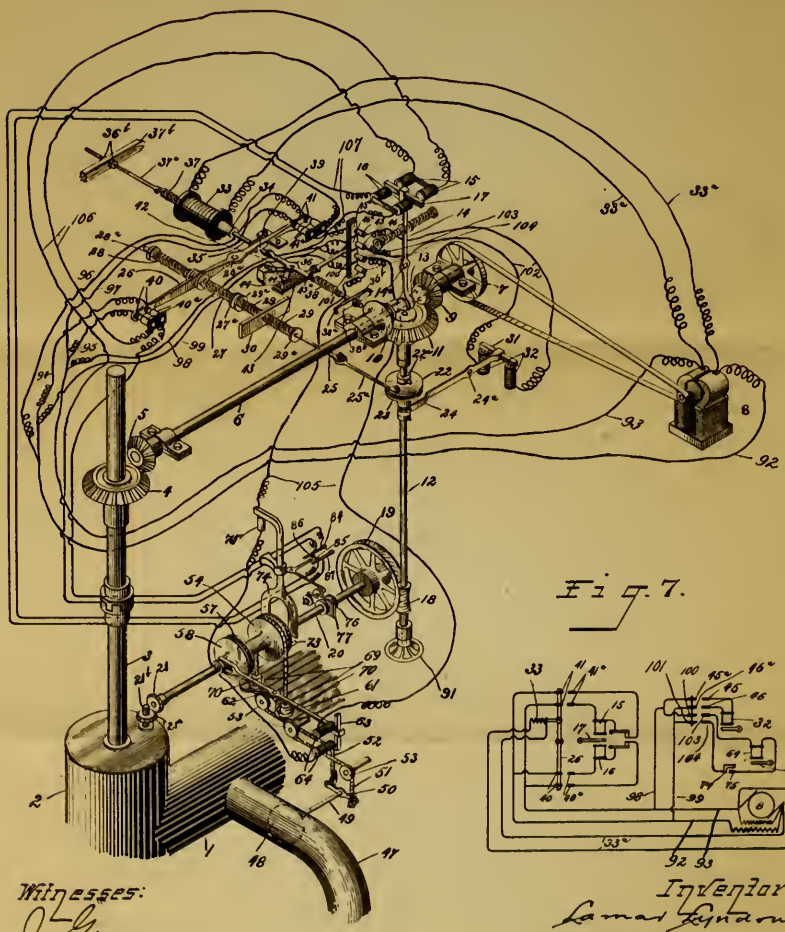


Fig. 7.

Witnesses:
J. Green
A. P. Knight

Inventor:
Lamar Lyndon
by Knight Bros
Attys

No. 695,220. Patented Mar. 11, 1902.

L. LYNDON.

ELECTROMECHANICAL WATER WHEEL GOVERNOR.

(Application filed Sept. 13, 1900.)

(No Model.) 4 Sheets—Sheet 2.

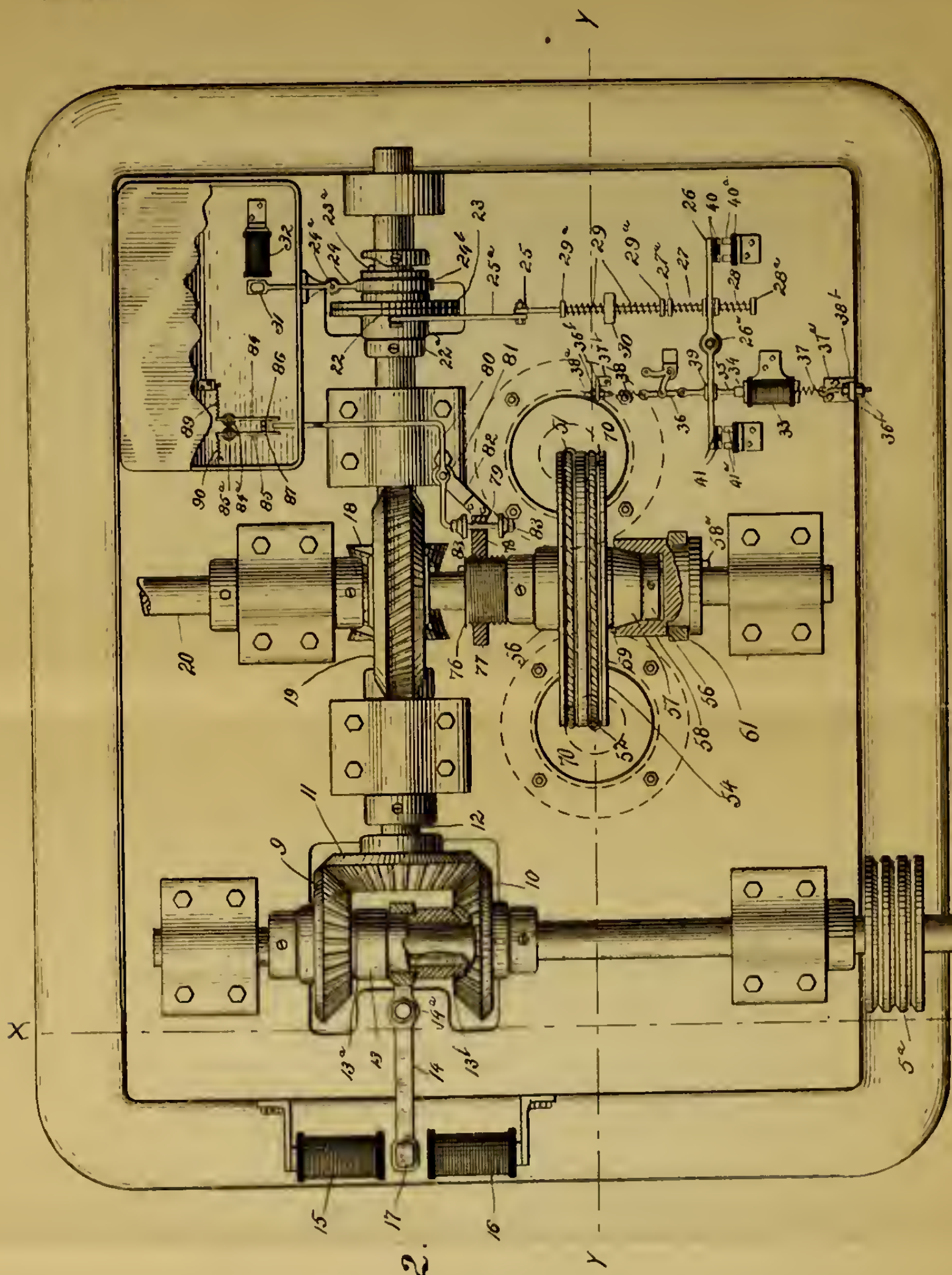


Fig. 2.

WITNESSES:

J. Green

A. D. Knight

INVENTOR

Lamar Lyndon

BY

Knight Bros

ATTORNEYS

No. 695,220. Patented Mar. 11, 1902.

L. LYNDON.

ELECTROMECHANICAL WATER WHEEL GOVERNOR.

(Application filed Sept. 13, 1900.)

(No Model.) 4 Sheets—Sheet 3.

Fig. 3.

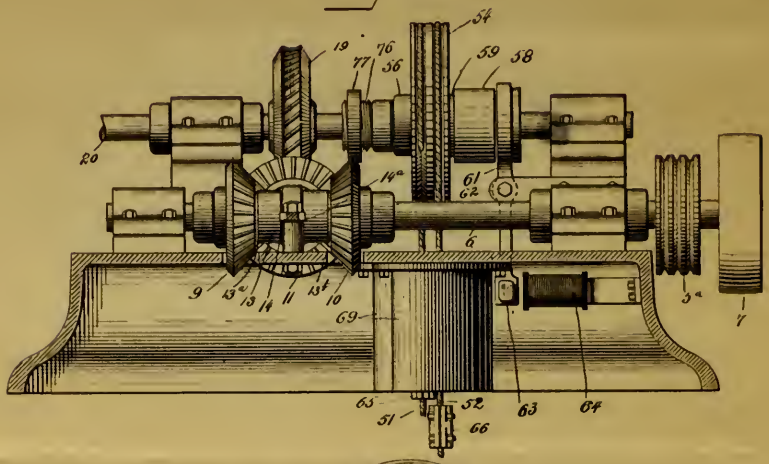
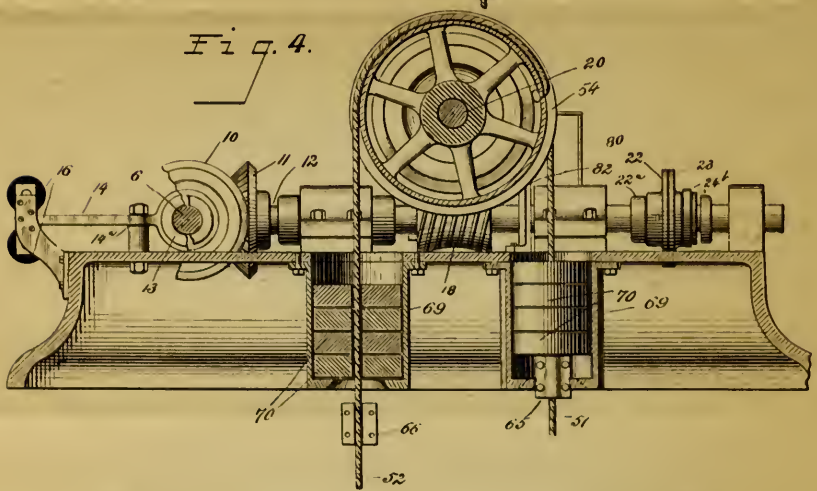


Fig. 4.



WITNESSES:

J. Green

A. P. Knight

INVENTOR

Lemuel Lyndon

BY

Knight Bros

ATTORNEYS.

No. 695,220. Patented Mar. 11, 1902.

L. LYNDON.

ELECTROMECHANICAL WATER WHEEL GOVERNOR.

(Application filed Sept 13, 1900.)

(No Model.) 4 Sheets—Sheet 4.

Fig. 5.

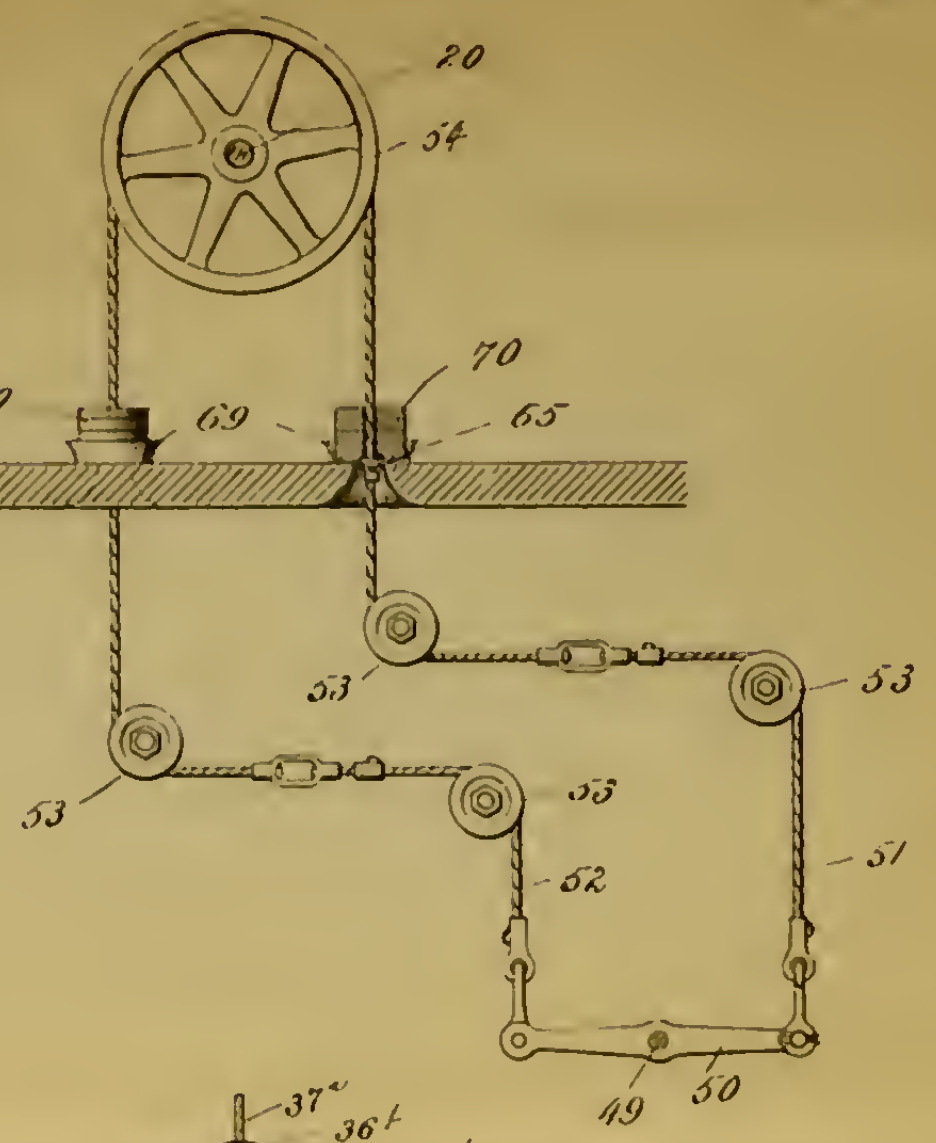
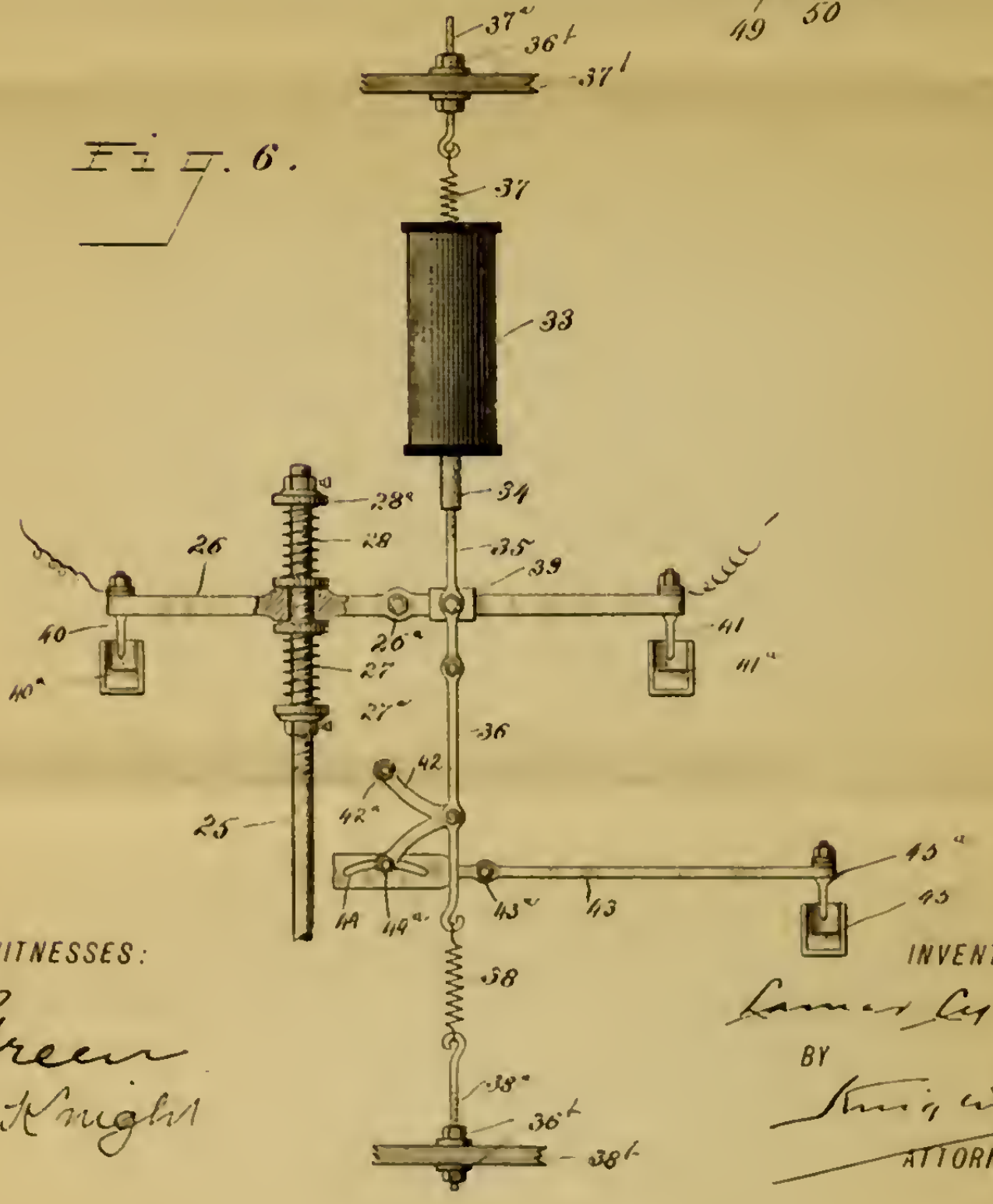


Fig. 6.



WITNESSES:

J. Green

A. P. Knight

INVENTOR

Lemuel Lyndon

BY

Munn & Co

ATTORNEYS.

UNITED STATES PATENT OFFICE.

LAMAR LYNDON, OF NEW YORK, N. Y.

ELECTROMECHANICAL WATER-WHEEL GOVERNOR.

SPECIFICATION forming part of Letters Patent No. 695,220, dated March 11, 1902.

Application filed September 13, 1900. Serial No. 29,880. (No model.)

To all whom it may concern:

Be it known that I, LAMAR LYNDON, of the borough of Manhattan, in the city, county, and State of New York, have invented certain new and useful Improvements in Electromechanical Water-Wheel Governors, of which the following is a specification.

The governors at present employed to regulate the water-supply to the water-wheel in general simply operate to open or close the water-wheel gate, thereby allowing of the admission of a greater or less supply of water. Now the first effect of such opening or closing of the gate, owing to the inertia of the water, is always the opposite to that which it is desired to bring about—*i. e.*, the opening of the gate operating to momentarily cause less velocity of water at the wheel, owing to the greater orifice the water has to flow through, and, vice versa, the closing of the gate operating to momentarily cause an increase of velocity, owing to the contraction of the orifice. Moreover, these contrary effects will last until the changed conditions can be imparted to the source of supply of water.

One object of my present invention is the overcoming of these opposite effects, and for this purpose I provide a by-pass inserted into the penstock or flume at a point near the water-gate and a gate in the said by-pass controlled by the same governing mechanism that controls the water-gate and operating to allow a greater or less flow through the by-pass, according as the water-gate is being closed or opened.

Other features of my invention relate to means for preventing excessive action of the governor in either direction, so that the governor is not allowed to pass beyond the proper point for regulation, by reason of the inertia of the parts or for other causes, thereby preventing the oscillation on either side of the regulating-point usual to such devices. Means are also provided for arresting the action of the governor when the water-gate is fully opened or closed.

Another feature of my invention relates to the control of the governor by a dynamo driven by the water-wheel and so wound that the electromotive force at the terminals is substantially independent of the load and varies with the speed, but at a rate greater than the speed variation, so as to obtain greater sensitiveness in regulation.

Other features of my invention relate to details of construction and arrangement, as hereinafter set forth.

Referring to the accompanying drawings, Figure 1 is a perspective and somewhat diagrammatic view of my improved water-wheel governor. Fig. 2 is a plan view showing in detail certain parts of same. Fig. 3 is a vertical section on the line X X of Fig. 2. Fig. 4 is a vertical section on the line Y Y of Fig. 2. Fig. 5 illustrates a part of my compensating device. Fig. 6 illustrates in detail a part of my controlling device. Fig. 7 is a diagram of the circuit connections.

In Fig. 1 I have shown the penstock 1 leading into the cylinder 2, the latter containing a turbine water-wheel. (Not shown.) 3 is the main shaft, connecting at one end with the water-wheel and carrying a bevel-gear 4, engaging with another bevel-gear 5 on a shaft 6, as shown in Fig. 1, or connected to drive such shaft 6 in any suitable manner by belt or rope connection to a sheave 5^a, (see Fig. 2,) this latter shaft being situated, preferably, at right angles to the main shaft 3. The shaft 6 carries a pulley 7, which is connected by belting to a dynamo 8. This shaft 6 also carries loosely-mounted bevel-gears 9 and 10. These bevel-gears are adapted to mesh with a third bevel-gear 11, mounted on a shaft 12, preferably at right angles to the shaft 6. Mounted on the shaft 6, so as to move longitudinally, but splined thereto, so as to rotate therewith, and located between the bevel-gears 9 and 10, is a sleeve 13, having friction-disks or chamfered ends 13^a 13^b or other form of clutch adapted to engage in holes in the bevel-gears 9 and 10, respectively. A lever 14, fulcrumed at 14^a, engages at one end in an annular groove in the sleeve 13, while the other end carries an armature 17, adapted to oscillate between the clutch-magnets 15 and 16.

On the shaft 12 is mounted a worm 18, meshing with a worm-wheel 19 on a shaft 20. The shaft 20 also carries a bevel or spur gear 21, which meshes with another bevel or spur gear 21^a, situated on the shaft 21^b, which operates the water-wheel gate, (the latter not shown.)

A disk 22 is mounted on shaft 12, so as to

be free to rotate, but is held from endwise movement by collars, one of which is shown at 22^a. On tho same shaft is a disk 23, normally out of contact with disk 22, but movable endwise on said shaft into contact with said disk, the disk being caused to rotate with the shaft by a spline connection 23^a. A lever 24, fulcrumed at 24^a to a fixed frame part, has a yoke 24^b engaging in an annular groove in the hub of disk 23 and carries the armature 31 of a magnet 32, herein termed the "returning-magnet." A returning device consisting of a rod 25, connected by a pivoted link or connecting-rod 25^a with the disk 22, passes through a hole in the controller-lever 26, pivoted at 26^a to a fixed support, and through a fixed abutment or frame-piece 30. Springs 27 28 are arranged on the rod between lever 26 and respective collars 27^a 28^a on the rod, while springs 29 29 are placed between collars 29^a 29^a on the rod and the fixed abutting piece 30, these latter springs serving to restore the returning device 25 to normal position after it has been displaced in either direction by the operating-clutch means 22 23. The springs 27 28 enable the returning-rod 25 to exert pressure on the controller 26 to return it to normal position, while permitting displacement of such controller from normal position under the action of its electromagnetic operating means. Such means consist of the solenoid 33, with its soft-iron core 34, carrying a rod 35, springs 37 38 being connected to said core and to a link 36, connected to said rod, so as to act reversely thereon and maintain the core in normal position when the water-wheel is at normal speed, the energization of the solenoid being responsive to such speed. The springs 37 38 are supported by screw-rods 37^a 38^a, adjustably secured by nuts 36^b to fixed supports on frame-pieces 37^b 38^b. The rod 35 is pivotally or loosely connected at 39 to the lever 26, which acts as a circuit-controller for the magnets 15 16 of the clutch-reversing gear, said lever carrying contacts 40 41 at its respective ends adapted to engage with fixed contacts 40^a 41^a, connected to the respective magnets aforesaid. The solenoid 33 also serves to control the action of the compensator-magnets and returning-magnets through a secondary controlling-lever 43, pivoted at 43^a to a fixed support and having a widened portion with a slot 44, engaged by a pin or roll 44^a on one end of a bell-crank 42, which is pivoted to a fixed part at 42^a, and whose other end is connected by link 36 to the rod 35, the slot being curved reversely to the arc of movement of pin or roll 44^a on the bell-crank, so that when the lever 26 and rod 35 move in either direction the lever 43 will be moved in one given direction. In such movement of the lever 43 contacts 45^a 46^a 100 101, carried thereby, will connect with fixed contacts 45 46 103 104 to close the circuit of the returning-magnet and the compensator-magnet, respectively.

The compensating devices comprise a by-pass 47, connected around the wheel and leading from the feeder-pipe or penstock at a point near the wheel-gate, the latter, however, being between the by-pass and the wheel. This by-pass is of an area which is a small percentage of the area of the feed-gate. A valve 48 in this by-pass is operated by ropes 51 52, attached to opposite ends of a lever 50 on the stem 49 of said valve, these ropes passing over idlers 53 and around pulley 54, being secured at the ends to said pulley. The double sheave or pulley 54 is mounted on shaft 20, so as to be free to rotate thereon, being held from endwise movement by collars 56. A clutch consisting of corresponding disks or cones 57 58, respectively, on said sheave and on hub 59, mounted on the shaft 20, so as to move endwise, but compelled to rotate therewith by spline connection 58^a, enables the sheave to be clutched to the shaft, this operation being controlled by a lever 61, pivoted at 62 and having a fork engaging in an annular groove in said hub. The other end of this lever carries the armature 63 of the compensator-magnet 64. On the ropes 51 52 are lugs or clamps or stops 65 66, adapted to engage under and lift weights 70 70 when the sheave is turned either way from normal position, these weights being guided in casings 69 on a suitable fixed support. Means may be provided for easing off the descent of these weights, if desired. For example, the casings 69 may constitute dash-pots.

Upon one side of the sheave 54 are pins, one of which is shown at 73. These pins are adapted to alternately engage a slide-bar 74 to lift same from contact with a contact-piece 75. The said slide-bar is returned to its normal position (which is in engagement with said contact-piece) by any ordinary means, such as gravity or a spring.

76 is a screw-threaded sleeve mounted upon and firmly secured to the shaft 20. A collar or sleeve 77, having a female screw part, is adapted to engage the screw-threaded sleeve 76. This collar of sleeve 77 has upon one side a projecting part 78, having a hole 79, through which passes an end of a rod or lever 80. This collar will therefore be prevented from rotating and will be constrained to move longitudinally of the sleeve. This sleeve is fulcrumed at 81 to a fixed piece 82 and carries on either side of the part 78 tappets 83 83. The other end of the rod or lever 80 projects between contact-levers 84 85, pivoted at 84^a 85^a and caused to normally press against the contact-points 86 87 by springs 89 90.

A hand-wheel 91 is adapted to engage the end of the shaft 12. This hand-wheel is readily removable for reasons hereinafter described.

The dynamo which I employ is compound wound and in a manner to give constant potential at the terminals with constant speed independent of the variation of the current. Wires 92 93 lead out from opposite sides of the armature. To these wires are connected,

first, wires 94 95, leading to the contacts 40; second, the wires 96 97, leading to the contacts 41, and, third, the wires 98 99, leading to to contacts 45^a 46^a on the lever 43 and also to contacts 100 and 101, situated on the same lever. The contacts 45 46, which coöperate with contacts 45^a 46^a, are connected together by wire 102, leading through magnet 32. Contacts 103 104, which coöperate with lever-contacts 100 101, are connected together by wire 105, leading through compensating magnet 64 and circuit-breakers 74 75. From the respective sets of contacts 40^a and 41^a wires 106 107 lead through clutch-magnets 15 16, such wires including the circuit-breakers 84 86 and 85 87. Wire 33^a leads from the dynamo to solenoid 33.

The operation of the device is as follows: When the speed of the main shaft 3, owing to an increase or decrease of the load thereon, is caused to fluctuate, the speed of the shaft 6, and consequently that of the armature of the dynamo 8, will also fluctuate. The dynamo which I employ is of the direct-current type, preferably of between three hundred and five hundred watts capacity. It is compound wound, the field-magnet being made up of soft laminated iron. The series winding is to be sufficient only to compensate for drop due to the internal resistance of the machine and to give at any given speed practically a constant potential at its terminal without regard to the quantity of current delivered by it when operating within its capacity. The fields are so proportioned that the magnetic density when the dynamo is running at normal speed is low and below the "knee" of the magnetic curve, say, ten thousand to twelve thousand lines per square centimeter in soft laminated iron. It is evident that a slight increase in speed of the armature will give an increase in voltage, due, first, directly to the increase in speed, and, second, to the increase in magnetic density, which latter increases because of a greater current flowing through the shunt-windings caused by the slight increase of voltage. Therefore a variation in speed of the armature will give a variation in voltage which will change much more rapidly than directly as the first power of the speed variation. The variation in voltage will be approximately as the square of the variation in speed of the armature. As the controlling-solenoid 33 responds directly to the square of the variation of voltage it will be seen that its control will be more sensitive than a control due simply to direct effect of the speed.

We will now assume the main shaft to be revolving clockwise as we look down upon it and also that it revolves at normal speed. Under these circumstances the solenoid 33 is energized to such an extent as to hold the controlling-lever 26 in its mean position, not making contact at either end, and the valve 48 in the by-pass is half open. Suppose that the load in the shaft has been decreased. The speed of shaft 6, and consequently of the pulley 7, will be increased, which will cause an increase of speed of the armature of the dynamo, and consequently of the electromotive force thereof. This will cause a greater than usual energizing of the controlling-solenoid 33, which will cause the core 34 to be drawn farther within it against the tensile force of the spring 37^b. The operation of the solenoid-core causes the contacts 40 to come in touch with their opposing contact-piece 40^a, thereby causing an excitation of the clutch-magnet 15. The armature 17 will now be drawn toward the magnet 15, thereby causing the end 13^a of the sleeve 13 to clutch the gear-wheel 9. The gear 9 will now be constrained to rotate with the shaft 6, and this will cause the gear-wheel 11, and consequently the shaft 12, to also rotate. The shaft 20 will therefore, through the worm 18 and worm-wheel 19, be caused to rotate and the water-gate will be closed.

In order that the shafts 12 and 20 may not tend to continue to revolve in either direction after the complete opening or closing of the gate, means must be provided for interrupting the circuit controlling the clutch-magnets. To this end I provide the screw-threaded sleeve 76 and collar 77, herein described. A certain number of revolutions of the shaft 12 will completely open or close the gate. The same number of revolutions will cause the collar 77 to travel the entire length of the sleeve 76. When the said collar arrives at a point near the end of the said sleeve, it will come in contact with one of the tappets 83, causing it, and consequently the rod or lever 80, to move with it. The other end of the rod, projecting, as it does, between the ends of the contact-levers 84 85, will cause one or the other of said levers (depending upon the direction of revolution of the shaft 12) to be lifted from contact with the contact-points 86 87, which operation will break the circuit of the corresponding clutch-magnet. This contact-lever will be kept out of contact until the shaft 12 is revolved in the opposite direction, when the collar 77 will travel away from it, thus allowing it to again come in contact with its contact-point. The rod 25, disks 22 and 23, and the controlling clutch-magnet 32 constitute a returning device for preventing the governor from overrunning—that is, moving the water-wheel gate a greater distance than is actually necessary for proper regulation—this necessitating a second movement of the gate in an opposite direction, which in turn may overtravel and require the gate to be moved back again. With an "overrunning" governor the gate movement is to a certain extent oscillatory, the amplitude of movement decreasing until the proper position of the gate is finally reached. When the governor-shaft 12 is set in operation in either direction by the controlling-solenoid 33, the rod 36 operates the lever 43 to close the circuit of the clutch-magnet 32, which causes engagement of disks 23 22 and causes

the disk 22 to be carried slightly around one way or the other, according to the direction of movement of the governor-shaft 12, thereby returning the lever 26 to normal position. This movement of the returning-rod 25 is resisted by spring 28 or 29, according to the direction of operation. As soon as the lever 26 is returned to normal position it operates directly through contacts 100 101 to deënergize the clutch-magnet which set the governor in operation and indirectly through lever 43 and contacts 46^a 46^b to deënergize the clutch-magnet for the returning device, the latter being thus released and returning to normal position under the influence of its spring. When the gate is operated, as above described, the lever 43 is moved to close the contacts 45^a 46^a 100 101, this closure being effected whatever the direction of movement of the controlling-lever 26 by reason of the pin and curved-slot connection between such levers. Current will therefore flow from the dynamo through wires 92 98, contacts 100 and 103, to wire 105, leading through the compensating magnet 32, and thence through contacts 74 75 and 104 101 to wires 99 93, back to the dynamo. Magnet 32 then engages clutch 58, and thus throws the by-pass valve into operative relation through the ropes 53, sheave 54, and clutch 58 with the gate-operating shaft 20. Consequently the by-pass valve will be turned toward open or shut position, according to whether the gate is closing or opening, for the purpose above stated. Normally the gate or valve in the by-pass will be half-way open, so that the amount of water flowing through the by-pass and around the wheel without doing work will be half the amount which the by-pass is capable of carrying. When the governor acts to close the main gate, the compensating device will open more widely the by-pass. The rapidity with which the valve in the by-pass opens is such that the increased volume of water which it allows to pass through is proportional to the decrease in area which the main gate effects by reason of its closing. Should the main gate open, a reverse action takes place. The object of this compensating device is to take care of the inertia effect of the column of water in the feed-pipe. As is well known, if a water-wheel gate be suddenly opened to increase the speed of the wheel the first effect will be to actually decrease the speed of the wheel, for the reason that the velocity of the water through the gate drops, because a larger area for the water to pass through is provided, and a larger volume of water is not immediately provided, because there is a time element required, which time element is the length of time required for gravity to accelerate the entire volume of water contained in the feed-pipe, which cannot be accomplished instantaneously. If the water-wheel gate be closed, a reverse effect will be noticed—that is, instead of decreasing the speed of the wheel the speed will actually rise, owing to increased velocity, through the water-wheel gate, due to a decreased area of opening, while the volume of water remains for the time constant, the volume decreasing only after a short time has elapsed, which length of time is required to arrest the column of water in the feed-pipe. It is obvious that the by-pass, arranged as described, opening or closing in a manner opposite to that in which the main gate opens or closes will, if properly adjusted, admit of the main gate being rapidly operated and the governing of the water-wheel quickly accomplished. After the governing takes place the by-pass gate is either open or closed, or nearly so, and in order to be useful for a second governing must return to its normal position. It, however, must return slowly in order that the effect of increased or decreased speed of water through both the by-pass gate and the water-wheel gate will not take place. It is here to be noted that all water-wheel governors as made to-day must accomplish their governing only at such a speed as the acceleration or retardation of the water in the column of the pipe can be accomplished, whereas in the case of the governor hereinbefore described, with the compensation-gate and actuating apparatus, the time element is removed from the main gate and the water-wheel and taken care of in the by-pass.

When the governing is completed, the controlling-solenoid allows the lever 26 to return to normal position, the circuit of the compensating magnet is broken by the return of rod 36 and lever 43, and the butterfly-valve returns slowly under the influence of its weight 70 to normal position.

Having thus described my invention, the following is what I claim as new therein and desire to secure by Letters Patent:

1. In a governor for water-wheels, the combination with a water-gate-operating shaft and a driving-shaft, of a reversing clutch-gear, adapted to connect the water-gate-operating shaft to the driving-shaft in reverse driving relations, means for reversely controlling the operation of such clutch-gear, a dynamo connected to be driven from the water-wheel and wound to maintain constant potential for varying currents therein, but to vary the potential in a greater ratio than the speed, an electromagnetic device connected to such dynamo, and controlling the clutch-gear-controlling means, and means for resisting the action of said electromagnetic device in such manner, that at normal speed the clutch mechanism will be disengaged, but on increase or decrease from normal speed the clutch will be operated to govern the water-gate through its operating-shaft.

2. In a governor for water-wheels, the combination with a water-gate-operating shaft and a driving-shaft, of a reversing clutch-gear, adapted to connect said shafts in reverse driving relations, electromagnetic means controlling such clutch-gear, a dynamo connect-

ed to be driven by the water-wheel and wound so as to deliver an electromotive force varying in a greater ratio than the speed of the water-wheel, a solenoid connected to said dynamo and a device controlled by said solenoid and carrying a contact device, and energizing connections for the electromagnetic gear-controlling means, controlled by said contact device.

3. In a water-wheel governor, the combination with a water-gate-operating shaft, and means for operating same in either direction to govern the water-wheel, of a controller for said operating means, responsive to changes of speed of the water-wheel, a returning device for said controller provided with a clutch connection to said operating-shaft, and means, actuated by said controller on movement thereof from normal position to engage said clutch with the said shaft, so as to cause the return of the controller to normal position and interrupt the governing action before it has overrun the proper amount, substantially as and for the purpose set forth.

4. In a water-wheel governor, the combination with a water-gate-operating shaft, a driving-shaft and reversing clutch-gear, adapted to turn the water-gate-operating shaft in either direction, a controller, responsive to changes of speed of the water-wheel and controlling such reversing-gear, and a returning device for said controller provided with actuating means controlled by said controlling means to return the controller to inoperative position, so as to prevent excessive movement of the governor.

5. In a water-wheel governor, the combination with a water-gate-operating shaft, a driving-shaft and a reversing clutch-gear, adapted to connect said shafts so as to cause the water-gate-operating shaft to move in either direction, a dynamo operatively connected to produce an electromotive force responsive to the speed of the water-wheel, a solenoid device energized by said dynamo, a core for said solenoid and a circuit-controller actuated thereby, springs for holding the circuit-controller in normal position, two electromagnetic devices for reversely operating the reversing clutch-gear, a returning device adapted, when operated, to return the circuit-controller to normal position, a clutch adapted to bring said returning device into operative connection with the water-gate-operating shaft, a magnet controlling said clutch and a circuit for said magnet including a circuit-closer operatively connected with the aforesaid circuit-controller and adapted to energize said magnet on movement of the circuit-controller in either direction.

6. In a water-wheel governor, the combination with means for operating the water-gate in either direction, a by-pass for the water-wheel, and a valve controlling said by-pass, of means connected to the water-gate-operating means and operating the by-pass valve inversely to the operation of the water-gate.

7. In a water-wheel governor, the combination with means for operating the water-gate in either direction from normal position, a by-pass for the water-wheel, and a valve for such by-pass, of means connected to the water-gate-operating means and adapted to operate the by-pass valve from normal position in either direction, so as to control such valve inversely to the control of the water-gate, during the governing action of the water-gate, and means for returning the by-pass valve to normal position on completion of governing movement of the water-gate-operating means.

8. In a water-wheel governor, the combination with a shaft for operating the water-gate in either direction from normal position, a by-pass for the water-wheel and a valve for such by-pass normally held in partly-open position, of an operating device for said valve provided with means for returning the valve to normal position, a clutch, adapted to connect said operating device for the by-pass valve with the water-gate-operating shaft to control the by-pass valve inversely to the water-gate, reversing means for operating the water-gate-operating shaft in either direction, a controller, responsive to the speed of the water-wheel and controlling said reversing means, and means operated by said controller to bring the aforesaid clutch into operation and to release said clutch when the governing action is effected.

9. In a water-wheel governor, the combination with a shaft adapted to operate the water-gate in either direction from normal position, a by-pass for the water-wheel and a valve for such by-pass, normally held in partly-open position, of means adapted to operate said valve in either direction and provided with means for returning the valve to normal position, a clutch, adapted to connect such operating means with the water-gate-operating shaft, a driving-shaft, and a reversing-gear for turning the water-gate-operating shaft in either direction, a dynamo connected to the water-wheel, so as to be responsive to the speed thereof, an electromagnetic device connected to said dynamo, a controller operated by said electromagnetic device and controlling the said reversing-gear, a magnetic device controlling the aforesaid clutch for the by-pass-operating means, a circuit for said magnet and means operated by said controller in its movement in either direction to close such circuit.

LAMAR LYNDON.

Witnesses:
A. P. KNIGHT,
HARRY E. KNIGHT.